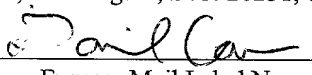


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SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, Reiko Kondo, a citizen of Japan residing at Kawasaki, Japan, Yutaka Shimizu, a citizen of Japan residing at Kawasaki, Japan and Atsushi Tanaka, a citizen of Japan residing at Kawasaki, Japan have invented certain new and useful improvements in

MAGNETIC HEAD HAVING A FLUX-GUIDE REGULATING FILM
REGULATING A MAGNETIC DOMAIN OF A FLUX GUIDE

of which the following is a specification : -

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TITLE OF THE INVENTION

MAGNETIC HEAD HAVING A FLUX-GUIDE
REGULATING FILM REGULATING A MAGNETIC DOMAIN OF A
FLUX GUIDE

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to
a magnetic head used in reproducing a signal
10 magnetic field from a magnetic recording medium such
as a hard disk, and, more particularly, to a
magnetic head of a type which induces the signal
magnetic field to a magnetoresistance film by
utilizing a magnetic guidance path (hereinafter
15 referred to as a flux guide) guiding the signal
magnetic field.

2. Description of the Related Art

A magnetic head of a magnetoresistance
type (hereinbelow referred to as an MR head) is a
20 reproducing head using a magnetoresistance film
(hereinbelow referred to as an MR film). A
reproduction by the MR head does not depend on a
relative speed between the MR head and a magnetic
recording medium such as a magnetic disk. Therefore,
25 the MR head is widely employed as a magnetic head
which contributes to intensifying a recording
density of a magnetic recording device and
miniaturizing a magnetic recording device.

Recently, however, as such a magnetic
30 recording device has come to have a mass capacity
with a high recording density, a bit length and a
track width on a magnetic recording medium have been
sharply becoming small and narrow. Accordingly, a
signal magnetic field from the magnetic recording
35 medium has been reducing; therefore, the MR head for
reproduction is needed to be more sensitive.

In order to provide the MR head with a

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higher sensitivity, magnetic domains of the MR film needs to be aligned so as to form a single magnetic domain. If the magnetic domains of the MR film fail to be aligned sufficiently into a single magnetic domain, a Barkhausen noise occurs so as to greatly fluctuate the output being reproduced. To tackle this problem, the MR film is provided with a magnetic-domain regulating film to regulate a magnetic domain of the MR film. It is known that such a highly coercive-force film as CoPt or such an antiferromagnetic film as PdPtMn can be used as the magnetic-domain regulating film.

In addition, a CPP structure has been proposed as one of structures that are designed to provide the MR head with a higher sensitivity, in which CPP structure an electric current flows in the direction of thickness of the MR film so as to achieve a great resistance change.

Besides, as a magnetic recording device has come to have a higher recording density, an MR circuit has been becoming finer and finer. In this trend, a conventional process of directly polishing the MR circuit inevitably has a limitation in terms of accuracy, which makes it difficult to produce the MR circuit with a good yield rate. To tackle this problem, it has been proposed that a magnetic head be provided with a flux guide so that the MR circuit is not directly polished.

The heretofore-mentioned techniques to provide the MR head with a higher sensitivity can be combined to produce a further preferable magnetic head.

However, when the above-mentioned flux guide has multiple magnetic domains, magnetic movements occurring in these magnetic domains are transmitted to the MR film, since a signal magnetic field from a magnetic recording medium first passes

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this flux guide. This causes a problem that, even if magnetic domains of the MR film themselves are sufficiently regulated, a Barkhausen noise occurs so as to inhibit a good reproduction.

5

SUMMARY OF THE INVENTION

It is a general object of the present invention to provide an improved and useful magnetic head in which the above-mentioned problems are
10 eliminated.

A more specific object of the present invention is to provide a magnetic head which can prevent noises so as to achieve a highly sensitive reproduction by aligning magnetic domains of a flux
15 guide, as well as of an MR film, into a single magnetic domain.

In order to achieve the above-mentioned objects, there is provided according to one aspect of the present invention a magnetic head comprising:

20 a magnetoresistance film;

a flux guide guiding a signal magnetic field from a magnetic recording medium to the magnetoresistance film; and

25 a flux-guide regulating film aligning magnetic domains of the flux guide into a single magnetic domain.

According to the present invention, magnetic domains of the flux guide are aligned into a single magnetic domain by the flux-guide
30 regulating film. Thus, the magnetic head according to the present invention can inhibit the occurrence of a Barkhausen noise so as to reproduce a signal magnetic field from a magnetic recording medium with a high sensitivity.

35 Additionally, in the magnetic head according to the present invention, the flux guide may be formed as a separate element from the

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According to the present invention, the flux guide having desired magnetic characteristics can be formed by using properly selected materials.

According to the present invention, the flux guide can be formed by using the magnetoresistance film. Therefore, a step of separately forming a flux guide becomes unnecessary.

According to the present invention, magnetic connection of the flux-guide regulating film with the flux guide can be adjusted selectively.

According to the present invention, the flux-guide regulating film can be so formed as to adequately regulate a magnetic domain of the flux guide.

According to the present invention, the flux-guide regulating film also regulates a magnetic domain of the magnetoresistance film. This simplifies a structure and manufacturing steps of the magnetic head.

In addition, a different magnetic-domain regulating film may be formed separately to regulate a magnetic domain of the magnetoresistance film, in consideration of magnetic characteristics of materials forming the flux guide or magnetic characteristics of materials forming the magnetoresistance film.

Additionally, in the magnetic head according to the present invention, the magnetoresistance film may be a magnetoresistance film of one of a spin-valve type and a tunnel-junction type.

According to the present invention, with a huge magnetoresistance effect of the magnetoresistance film of the spin-valve type, the magnetic head according to the present invention can reproduce a signal magnetic field from a magnetic recording medium with a high sensitivity.

Furthermore, using the magnetoresistance film of the tunnel-junction type can make the magnetic head more sensitive. In this case, the magnetic head has a CPP structure.

In order to achieve the above-mentioned objects, there is also provided according to another aspect of the present invention a magnetic reproducing device comprising:

- a magnetic head including:
 - a magnetoresistance film;
 - a flux guide guiding a signal magnetic field from a magnetic recording medium to the magnetoresistance film; and
 - a flux-guide regulating film aligning magnetic domains of the flux guide into a single magnetic domain.

According to the present invention, the magnetic reproducing device can reproduce magnetic information recorded on the magnetic recording

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medium with a high sensitivity.

Other objects, features and advantages of the present invention will become more apparent from the following detailed description when read in
5 conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is an illustration of a main structure of a magnetic head of a magnetoresistance
10 type (an MR head) according to a first embodiment of the present invention;

FIG.2A is a first illustration of manufacturing steps of the MR head according to the first embodiment of the present invention;

15 FIG.2B is a second illustration of the manufacturing steps of the MR head according to the first embodiment of the present invention;

FIG.3A is a third illustration of the manufacturing steps of the MR head according to the
20 first embodiment of the present invention;

FIG.3B is a fourth illustration of the manufacturing steps of the MR head according to the first embodiment of the present invention;

FIG.4A is a fifth illustration of the manufacturing steps of the MR head according to the
25 first embodiment of the present invention;

FIG.4B is a sixth illustration of the manufacturing steps of the MR head according to the first embodiment of the present invention;

30 FIG.5A is a seventh illustration of the manufacturing steps of the MR head according to the first embodiment of the present invention;

FIG.5B is an eighth illustration of the manufacturing steps of the MR head according to the
35 first embodiment of the present invention;

FIG.6A is a ninth illustration of the manufacturing steps of the MR head according to the

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first embodiment of the present invention;

FIG.6B is a tenth illustration of the manufacturing steps of the MR head according to the first embodiment of the present invention;

5 FIG.7 is an illustration of a main structure of an MR head according to a second embodiment of the present invention;

10 FIG.8A is a first illustration of manufacturing steps of the MR head according to the second embodiment of the present invention;

FIG.8B is a second illustration of the manufacturing steps of the MR head according to the second embodiment of the present invention;

15 FIG.9A is a third illustration of the manufacturing steps of the MR head according to the second embodiment of the present invention;

FIG.9B is a fourth illustration of the manufacturing steps of the MR head according to the second embodiment of the present invention;

20 FIG.10A is a fifth illustration of the manufacturing steps of the MR head according to the second embodiment of the present invention;

25 FIG.10B is a sixth illustration of the manufacturing steps of the MR head according to the second embodiment of the present invention;

FIG.11A to FIG.11C are illustrations showing styles of connection of a flux-guide regulating film with a flux guide; and

30 FIG.12 is an illustration of a main structure of a recording and reproducing device for a magnetic recording medium.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

35 A description will now be given, with reference to the drawings, of embodiments according to the present invention.

FIG.1 is an illustration of a main

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structure of a magnetic head 100 of a magnetoresistance type (hereinbelow referred to as an MR head 100) according to a first embodiment of the present invention. In FIG.1, such elements as electrode terminals are omitted from the drawing for the purpose of making it easy to show features of the MR head 100. A more detailed structure of the MR head 100 is made known hereinafter in explaining manufacturing steps of the MR head 100.

In FIG.1, SW indicates the direction of width, SH indicates the direction of height, and MT indicates the direction of thickness. Hsig indicates a signal magnetic field from a magnetic recording medium.

In the MR head 100 according to the first embodiment, a flux-guide regulating film 12 regulating a magnetic domain of a flux guide 8 also functions as a magnetic-domain regulating film regulating a magnetic domain of a magnetoresistance film 10 (hereinbelow referred to as an MR film 10). The flux guide 8 and the MR film 10 of the MR head 100 according to the present embodiment are formed as separate elements.

In the present description, a regulating film regulating a magnetic domain of a flux guide is distinctively referred to as a "flux-guide regulating film", while a regulating film regulating a magnetic domain of an MR film is, as conventionally, referred to as a magnetic-domain regulating film.

A spin-valve MR film as a huge magnetoresistance film or a tunnel-junction MR film can be used as the MR film 10. The spin-valve MR film includes a spin-valve film of NiFe/Cu/NiFe/IrMn/etc. and a spin-valve film of a ferri-lamination type having a laminated structure of NiFe/Cu/CoFeB/Ru/CoFeB/PdPtMn. The tunnel-

junction MR film includes a film of
NiFe/Al₂O₃/NiFe/PdPtMn.

By the way, since the MR head 100
according to the present embodiment uses a flux
5 guide, the signal magnetic field Hsig tends to
diminish as compared to a magnetic head not having a
flux guide. Therefore, the MR head 100 is preferred
to employ a more sensitive MR film, especially the
tunnel-junction MR film as the MR film 10, because
10 the tunnel-junction MR film is highly sensitive.
The tunnel-junction MR film requires a sensing
current to flow in a perpendicular direction as to
the surface thereof (the thickness direction MT);
therefore, when the tunnel-junction MR film is used
15 in the MR head 100, the MR head 100 has a CPP
structure.

Hence, the MR head 100 according to the
present embodiment is illustrated as a CPP type. It
is noted that a spin-valve film can be also used in
20 the MR head of a CPP type.

The flux guide 8 is formed on the side of
the MR film 10 near to a magnetic recording medium
in the height direction SH so as to be magnetically
connected to the MR film 10. The flux guide 8
25 protrudes from the above-mentioned side of the MR
film 10 in the height direction SH. The flux-guide
regulating film 12 is provided so as to regulate the
alignment of magnetic domains of the flux guide 8
into a single magnetic domain. The flux-guide
30 regulating film 12 is formed on each side of the
flux guide 8 in the width direction SW so as to be
magnetically connected to the flux guide 8.

Additionally, the flux-guide regulating
film 12 is extended in the height direction SH so as
35 to be magnetically connected also to each side of
the MR film 10 so that the flux-guide regulating
film 12 also functions as the magnetic-domain

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regulating film for the MR film 10.

The MR head 100 according to the present embodiment regulates magnetic domains of the flux guide 8 and the MR film 10 by using a single regulating film. This arrangement simplifies the structure and manufacturing steps of the MR head 100. Of course, a magnetic-domain regulating film may be provided separately to regulate a magnetic domain of the magnetoresistance film 10.

Such a soft-magnetic material as NiFe can be used as the above-described flux guide 8. Such a highly coercive-force film as CoCrPt or such an antiferromagnetic film as PdPtMn can be used as the flux-guide regulating film 12.

The MR head 100 according to the present embodiment has a flux guide 9 on the opposite side to the flux guide 8 in the height direction SH, the flux guide 9 being for leading out a magnetic field. Functions of the flux guide 9 will be described hereinafter. In the following description, the flux guide 8 is referred to as a under flux guide 8, and the flux guide 9 is referred to as an upper flux guide 9. The (under) flux guide 8 is more closely associated with the present invention.

Next, a description will be given, with reference to FIG.2A to FIG.6B, of manufacturing steps of the above-described MR head 100. FIG.2A to FIG.6B show a series of the manufacturing steps of the MR head 100. In FIG.2A to FIG.6B, a figure on the right side is a view as seen from the thickness direction MT (from above in FIG.1), a figure at the center is a cross-sectional view taken along line Y-Y in the width direction SW, and a figure on the left side is a cross-sectional view taken along line X-X in the height direction SH.

Hereinbelow, descriptions are given from FIG.2A to FIG.6B in order. First, in FIG.2A, a

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In FIG.3A, an electrode terminal 6 is formed on the electrode terminal 3 in the above-mentioned opening before removing the resist 5. The resist 5 is removed thereafter. At this point, the electrode terminal 3 and the electrode terminal 6 are electrically connected to each other. As mentioned above, the MR head 100 according to the present embodiment has a CPP structure. The electrode terminal 3 and the electrode terminal 6 will become a under electrode of the MR film 10 that is to be formed subsequently.

The flux path 7 has a function of
35 connecting the shield 1 with the upper flux guide 9
that is to be formed in the following steps.
Incorporating this structure facilitates the influx

of the signal magnetic field H_{sig} from the under flux guide 8.

In FIG.4A, the under flux guide 8 and the upper flux guide 9 are formed in the same manner as the flux path 7. In this step, the under flux guide 8 and the upper flux guide 9 are so formed as not to be electrically connected to the electrode terminals 3 and 6. Although it is preferable that the upper flux guide 9 contacts the flux path 7, it does not matter whether or not the upper flux guide 9 electrically connects to the flux path 7, as long as the upper flux guide 9 is so adjacent to the flux path 7 as to magnetically connect thereto.

Next, in FIG.4B, the MR film 10 is formed by such a method as sputtering, and then a resist 11 is formed and patterned so as to be used as a mask in patterning the MR film 10 into a predetermined shape. In this course, the MR film 10 is formed so as to overlap a part of each of the under flux guide 8 and the upper flux guide 9. Although it is preferable that the MR film 10 contacts the surface of each of the under flux guide 8 and the upper flux guide 9, it does not matter whether or not the MR film 10 electrically connects to each of the under flux guide 8 and the upper flux guide 9, as long as the MR film 10 is so adjacent to each of the under flux guide 8 and the upper flux guide 9 as to magnetically connect thereto.

As mentioned above, a spin-valve MR film or a tunnel-junction MR film can be used as the MR film 10. The MR film 10 is so formed that the under flux guide 8 and the upper flux guide 9 have a free magnetic layer.

In FIG.5A, a resist 20 is formed and patterned so as to be used as a mask in etching a part of the MR film 10 and parts of the under flux guide 8 and the upper flux guide 9. Then, the flux-

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guide regulating film 12 is formed by such a method as sputtering before removing the resist 20.

5 In this step, the flux-guide regulating film 12 is formed on each side of the under flux guide 8, the MR film 10 and the upper flux guide 9 so as to create a state in which the flux-guide regulating film 12 regulates magnetic domains of the under flux guide 8, the MR film 10 and the upper flux guide 9.

10 Next, the flux-guide regulating film 12 is patterned into a predetermined shape by using a resist, though not shown in the figures. At this point, as seen in the figure on the right side on FIG.5B, it does not matter whether the upper end of
15 the upper flux guide 9 is even with or below the upper end of the flux-guide regulating film 12, as long as the upper end of the upper flux guide 9 is not above the upper end of the flux-guide regulating film 12.

20 Next, in FIG.5B, an electrode terminal 13 is formed, and then a resist 14 is formed and patterned so as to be used as a mask in patterning the electrode terminal 13.

Then, in FIG.6A, an insulating film 15 is
25 formed before removing the resist 14, and thereafter the resist 14 is removed. Finally, in FIG.6B, a shield 16 is formed. At this point, the electrode terminal 13 and the shield 16 are electrically connected with each other. Since the electrode
30 terminal 13 is formed on the MR film 10, the shield 16 becomes an upper electrode. The MR head 100 according to the present embodiment has a CPP structure in which the above-described electrode terminal 3 and the shield 16 are the electrodes
35 formed under and on the MR film 10 so that a detecting current flows in the thickness direction MT.

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The MR head 100 as shown in FIG.1 is manufactured by the heretofore-mentioned manufacturing steps. In addition, in the above-mentioned steps, the shields 1 and 16 and the electrode terminals 3, 6 and 13 can be formed by such a method as plating, deposition or sputtering. The insulating films 2, 4 and 15 can be formed by such a method as sputtering.

Since the flux-guide regulating film 12 surely regulates the alignment of magnetic domains of the flux guide 8 into a single magnetic domain, the above-described MR head 100 can inhibit the occurrence of a Barkhausen noise and thus can reproduce a signal magnetic field from a magnetic recording medium with high sensitivity.

FIG.7 is an illustration of a main structure of an MR head 200 according to a second embodiment of the present invention. In FIG.7, as in FIG.1, such elements as electrode terminals are omitted from the drawing for the purpose of making it easy to show features of the MR head 200. A more detailed structure of the MR head 200 is made known hereinafter in explaining manufacturing steps of the MR head 200. Also in FIG.7, SW indicates the direction of width, SH indicates the direction of height, MT indicates the direction of thickness, and Hsig indicates a signal magnetic field from a magnetic recording medium.

Also in the MR head 200 according to the second embodiment, the flux-guide regulating film also functions as a magnetic-domain regulating film regulating a magnetic domain of an MR film. However, in the MR head 200 according to the present embodiment, a flux guide is formed as a part of the MR film. It is noted here that elements in the second embodiment that are identical or equivalent to the elements described in first embodiment are

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A spin-valve MR film as a huge magnetoresistance film or a tunnel-junction MR film can be used as an MR film 30 of the MR head 200 according to the present embodiment. The spin-valve MR film includes a spin-valve film of NiFe/Cu/NiFe/IrMn/etc. and a spin-valve film of a ferri-lamination type having a laminated structure of Ni/Cu/CoFeB/Ru/CoFeB/PdPtMn. The tunnel-junction MR film includes a film of NiFe/Al₂O₃/NiFe/PdPtMn. It is noted that the MR head 200 also has a CPP structure.

Therefore, the MR head 200 can provide the same
25 effect as the MR head 100 according to the first
embodiment without having the upper flux guide 9.

30 shown in FIG.2A to FIG.3B of the first embodiment
are equivalent in the present embodiment. Therefore,
the following description skips the steps equivalent
to the steps shown in FIG.2A to FIG.3B, and starts
with a step shown in FIG.8A.

35 In FIG.8A, the MR film 30 is formed
because a material forming a flux guide does not
have to be formed. The above-mentioned spin-valve

MR film or the tunnel-junction MR film can be used as the MR film 30.

Next, in FIG.8B, the resist 11 is formed and patterned so as to be used as a mask in
5 patterning the MR film 30 into a predetermined shape having at least a free magnetic layer. It is noted that not only a nonmagnetic layer (Cu or Al_2O_3) on the free magnetic layer but also a part of a pinned magnetic layer on the nonmagnetic layer may be left
10 as a part of the MR film 30.

In this step, the flux guide 31 is formed as an extended part of the MR film 30.

In FIG.9A, the resist 20 is formed and patterned so as to be used as a mask in etching the
15 MR film 30. Thereafter, the flux-guide regulating film 12 is formed by such a method as sputtering before removing the resist 20. In this step, the flux-guide regulating film 12 is formed on each side of the MR film 30 including the flux guide 31.

20 Next, the flux-guide regulating film 12 is patterned into a predetermined shape by using a resist, though not shown in the figures. At this point, as seen in the figure on the right side on FIG.9B, it does not matter whether the upper end of
25 the flux-guide regulating film 12 is even with or above the upper end of the MR film 30, as long as the upper end of the flux-guide regulating film 12 is not below the upper end of the MR film 30.

Next, in FIG.9B, the electrode terminal 13
30 is formed, and then the resist 14 is formed and patterned so as to be used as a mask in patterning the electrode terminal 13.

Then, in FIG.10A, the insulating film 15
35 is formed before removing the resist 14, and thereafter the resist 14 is removed. Finally, in FIG.10B, the shield 16 is formed. At this point, the electrode terminal 13 and the shield 16 are

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electrically connected with each other. The MR head 200 according to the present embodiment also has a CPP structure.

5 Since the flux-guide regulating film 12 surely regulates magnetic domains of the flux guide 31 formed as a part of the MR film 30, the above-described MR head 200 can reproduce a signal magnetic field from a magnetic recording medium with high sensitivity.

10 According to the second embodiment, the flux guide is formed as a part of the MR film 30, and thus a step of separately forming a flux guide is unnecessary. This simplifies the manufacturing steps of the MR head.

15 In the heretofore-described first and second embodiments, the flux-guide regulating film 12 is formed on each side of the flux guide 8 (31), as shown in FIG.11A. However, the style of magnetic connection of the flux-guide regulating film 12 with
20 the flux guide 8 (31) is not limited to this. For example, the outer surface of the flux-guide regulating film 12 may be connected to the inner surface of the flux guide 8 (31), as shown in FIG.11B. Further, the flux-guide regulating film 12
25 may be connected to the inner surface and each side of the flux guide 8 (31), as shown in FIG.11C.

In order to provide the style of magnetic connection shown in FIG.11B, the step shown in FIG.5A can be so changed that the flux-guide
30 regulating film 12 is formed and processed before etching the under flux guide 8. Also, in order to provide the style of magnetic connection shown in FIG.11C, the step shown in FIG.5A can be so changed that the flux-guide regulating film 12 is formed and
35 etched before forming the under flux guide 8.

Since the styles of magnetic connection shown in FIG.11B and FIG.11C enable closer magnetic

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5 In the above-described first and second
embodiments, the flux-guide regulating film also
functions as a magnetic-domain regulating film
regulating a magnetic domain of the MR film.
However, the present invention is not limited to
10 these embodiments, and another magnetic-domain
regulating film may be formed separately to regulate
the magnetic domain of the MR film.

Next, a description will be given of a recording and reproducing device for a magnetic recording medium, the recording and reproducing device having the MR head according to the above-mentioned embodiments mounted therein. FIG.12 is an illustration of a main structure of the recording and reproducing device. A recording and reproducing device 300 for a magnetic recording medium has a hard disk 301 mounted therein as a magnetic recording medium that is caused to rotate. A complex magnetic head 350 includes, for example, the MR head 100 according to the first embodiment facing the surface of the hard disk 301 for reproducing with a predetermined distance therebetween. The complex magnetic head 350 is used to perform a magnetic reproduction. The complex magnetic head 350 is fixed on the tip of a slider 303 at the end of an arm 302. The complex magnetic head 350 can be

Although the magnetic recording and reproducing device shown in FIG.12 uses the MR head 100 according to the first embodiment, the magnetic recording and reproducing device may also employ the MR head 200 according to the second embodiment of the present invention.

The present application is based on
15 Japanese priority application No.2001-052825 filed
on February 27, 2001, the entire contents of which
are hereby incorporated by reference.